CLAIMS

1. A silicon casting apparatus comprising:

a mold for holding a silicon melt therein, comprising a bottom plate and a side plate raised upward from a peripheral edge of the bottom plate;

a heating mechanism disposed above the mold; and

a cooling mechanism disposed below the mold,

for causing a temperature gradient in the silicon melt within the mold due to heating by the heating mechanism and cooling by the cooling mechanism, to subject the silicon melt to unidirectional solidification upward from the bottom plate side of the mold, characterized in that

the mold and the heating mechanism are disposed with the distance therebetween kept constant, and

the cooling mechanism comprises a bottom cooling member for cooling a bottom surface of the mold that is a lower surface of the bottom plate,

the bottom cooling member having a heat receiving surface disposed opposed to a heat radiation surface that is

(1) the bottom surface of the mold or

(2) a surface, other than a placement surface, of a pedestal on which the mold is placed with the bottom surface thereof being in contact with the placement surface

and constituting a heat exchange region together with the heat radiation surface,

and is moved relative to the mold or the pedestal in order to change the heat exchange area between the heat radiation surface and the heat receiving surface that are opposed to each other.

2. The silicon casting apparatus according to claim 1, wherein the bottom cooling member is moved in a plane direction of the heat radiation surface relative to the mold or the pedestal while maintaining a state where the heat receiving surface thereof is kept in direct contact with the heat radiation surface in order to change the heat exchange area.

3. The silicon casting apparatus according to claim 1, wherein the bottom cooling member is moved in a plane direction of the heat radiation surface relative to the mold or the pedestal while maintaining a state where the heat receiving surface thereof is spaced a predetermined gap apart from the heat radiation surface in order to change the heat exchange area.

4. The silicon casting apparatus according to claim 3, wherein the gap between the heat radiation surface and the heat receiving surface is not more than 10 mm.

5. The silicon casting apparatus according to claim 1, wherein a thermal conductivity of the pedestal is not less than 40 W/(m·K).

6. The silicon casting apparatus according to claim 5, wherein the pedestal has one surface serving as the placement surface, the placement surface and a surface on the opposite side thereof being parallel to each other and formed to a constant thickness, and the thickness is not less than one-sixth of a stretch length of a contact region between the placement surface and the bottom surface of the mold placed thereon.

7. The silicon casting apparatus according to claim 1, comprising

temperature detection unit for measuring a temperature of the mold, and

control unit for controlling a state of heating by the heating mechanism and the heat exchange area of the heat exchange region in the cooling mechanism on the basis of the temperature of the mold measured by the temperature detection unit, to control a solidification speed of the

silicon melt.

8. The silicon casting apparatus according to claim 1, comprising inert gas discharge unit for spraying inert gas on the silicon melt held inside the mold, the inert gas discharge unit being disposed with a distance from the mold and the heating mechanism kept constant.

9. A silicon casting apparatus comprising:

a mold for holding a silicon melt therein, comprising a bottom plate and a side plate raised upward from a peripheral edge of the bottom plate;

a heating mechanism disposed above the mold; and

a cooling mechanism disposed below and beside the mold,

for causing a temperature gradient in the silicon melt within the mold due to heating by the heating mechanism and cooling by the cooling mechanism, to subject the silicon melt to unidirectional solidification upward from the bottom plate side of the mold, characterized in that

the mold and the heating mechanism are disposed with the distance therebetween kept constant,

the cooling mechanism comprises a bottom

cooling member for cooling a bottom surface of the mold that is a lower surface of the bottom plate and a side cooling member for cooling a side surface of the mold that is an outer side surface of the side plate, and

the side cooling member having a heat receiving surface disposed opposed to the side surface of the mold and constituting a heat exchange region together with the side surface, and is moved relative to the mold in order to enlarge the heat exchange region from a lower part to an upper part in order in the height direction of the mold.

10. The silicon casting apparatus according to claim 9, wherein the side cooling member is moved in a plane direction of the heat radiation surface from the lower part to the upper part in order relative to the mold, while maintaining a state where the heat receiving surface thereof is kept in direct contact with the side surface of the mold, in order to enlarge the heat exchange region formed on the side surface of the mold from the lower part to the upper part in order in the height direction of the mold.

11. The silicon casting apparatus according to claim 9, wherein the side cooling member

comprises a plurality of cooling sections respectively having divisional heat receiving surfaces into which the heat receiving surface opposed to the side surface of the mold is divided in the height direction of the mold, and each of the cooling sections is relatively moved individually between a state where the divisional heat receiving surface is contact with or near the side surface and a state where the divisional heat receiving surface is spaced apart from the side surface in order to enlarge the heat exchange region formed on the side surface of the mold form the lower part to the upper part in order in the height direction of the mold.

12. The silicon casting apparatus according to claim 9, wherein

the bottom cooling member has a heat receiving surface disposed opposed to a heat radiation surface that is

(1) the bottom surface of the mold or

(2) a surface, other than a placement surface, of a pedestal on which the mold is placed with the bottom surface thereof being in contact with the placement surface

and constituting a heat exchange region together with the heat radiation surface,

and is moved relative to the mold or the pedestal in order to change the heat exchange area between the heat radiation surface and the heat receiving surface that are opposed to each other.

13. The silicon casting apparatus according to claim 12, wherein the bottom cooling member comprises a plurality of cooling sections respectively having divisional heat receiving surfaces into which the heat receiving surface disposed opposed to the bottom surface of the mold and constituting the heat exchange region together with the bottom surface is divided at a center and a peripheral edge of the bottom surface of the mold, each of the cooling sections is relatively moved individually between a state where the divisional heat receiving surface is contact with or near the bottom surface and a state where the divisional heat receiving surface is spaced apart from the bottom surface in order to enlarge the heat exchange region formed on the bottom surface of the mold from the center to the peripheral edge of the bottom surface in order.

14. The silicon casting apparatus according to claim 9, comprising

temperature detection unit for measuring a temperature of the mold, and

control unit for controlling a state of heating by the heating mechanism and the heat exchange area of the heat exchange region in the cooling mechanism on the basis of the temperature of the mold measured by the temperature detection unit to control a solidification speed of the silicon melt.

15. The silicon casting apparatus according to claim 9, comprising inert gas discharge unit for spraying inert gas on the silicon melt held inside the mold, the inert gas discharge unit being disposed with a distance from the mold and the heating mechanism kept constant.

16. A method of producing polycrystal silicon ingot using the silicon casting apparatus according to any one of claims 1 to 15, characterized by comprising the steps of: holding a silicon melt inside a mold comprising a bottom plate and a side plate raised upward from a peripheral edge of the bottom plate; and subjecting the silicon melt to unidirectional solidification upward from the bottom plate side of the mold while increasing a heat exchange area of a heat exchange region formed between a heat radiation surface of at least one of the bottom plate side and the side plate side of the mold and

a heat receiving surface of a cooling mechanism opposed to the heat radiation surface, disposed below the mold or below and beside the mold, as a solid-liquid interface of the silicon melt inside the mold rises due to cooling by the cooling mechanism, with the distance between a heating mechanism disposed above the mold and the mold kept constant.

17. The method of producing silicon ingot according to claim 16, wherein the silicon melt is subjected to unidirectional solidification upward from the bottom plate side of the mold while controlling the state of heating by the heating mechanism and the heat exchange area of the heat exchange region of the cooling mechanism by the control unit on the basis of a temperature of the mold measured by the temperature detection unit.

18. The method of producing silicon ingot according to claim 16, wherein the silicon melt held inside the mold is subjected to unidirectional solidification upward from the bottom plate side of the mold while spraying inert gas on the silicon melt from an insert gas discharging unit.